(19) Europäisches Patentamt
European Patent Office
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(11) EP 1 093 210 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.04.2001 Bulletin 2001/16

(51) Int. Cl.^{7}: **H02K 29/08**

(21) Application number: **00122557.2**

(22) Date of filing: **16.10.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **15.10.1999 JP 29421199**

(71) Applicant:
YAMAHA HATSUDOKI KABUSHIKI KAISHA
Iwata-shi Shizuoka-ken (JP)

(72) Inventor:
Taiken, Matsui,
c/o Yamaha Hatsudoki K.K.
Shizuoka-ken (JP)

(74) Representative:
Grünecker, Kinkeldey,
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(54) **Electrical driving apparatus**

(57) To continuously detect a position of a rotor of a motor having the rotor formed with a plurality of magnetic poles by permanent magnets without using an expensive encoder, the rotor position is continuously detected by arranging a rotor formed with, for example, 8 poles by permanent magnets, a stator having, for example, 9 slots of magnetic legs opposed to the rotor, an analog type Hall element arranged at a position opposed to the magnetic poles of the rotor, an analog type Hall sensor for outputting an analog magnetism detecting signal the phase of which is shifted by 90° from that of the analog type Hall sensor or a digital type Hall sensor for out-putting a digital magnetism detecting signal comprising a binary signal and comparing the magnetism detecting signals having different phases by 90°.

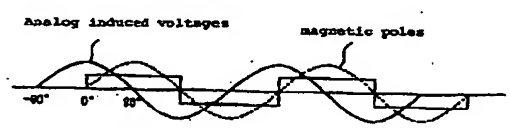

FIGURE 3

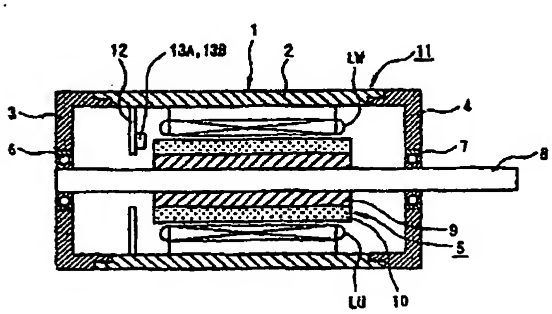

FIGURE 1

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type Hall sensor in correspondence with the magnetic fluxes of the magnetic poles, wherein the rotational position detecting means detects the rotational position of the rotor based on the analog magnetism detecting signal outputted from the analog type Hall sensor and the digital magnetism detecting signal outputted from the digital type Hall sensor.

[0012] According to another preferred aspect of the invention, when only a range of, for example, -90° through 90° is considered, the analog magnetism detecting signal in the shape of the sine wave outputted from the analog type Hall sensor can detect accurate rotational position since an instantaneous value thereof is changed in accordance with the rotational position. However, in a range of 90° through 270°, the individual instantaneous value becomes a value the same as that of the instantaneous value in the range of 90° through -90° and accordingly, when operation processing is carried out by using the instantaneous value, those at 60° and at 120° cannot be discriminated from each other. Therefore, by outputting the digital magnetism detecting signal comprising the binary signal from the digital type Hall sensor having the phase difference of 90° relative to the analog signal of the analog type Hall sensor, by the digital magnetism detecting signal, whether the analog magnetism detecting signal falls in the range of -90° through 90° or the range of 90° through 270° can be determined.

[0013] Hereinafter, the present invention is explained in greater detail by means of preferred embodiments thereof in conjunction with the accompanying drawings, wherein:

Fig. 1 is an outline constitution view showing a first embodiment when the invention is applied to a brushless DC motor of an inner rotor type;

Fig. 2 is an explanatory view showing a relationship of arranging the rotor and a stator of Fig. 1;

Fig. 3 is a characteristic diagram showing an output characteristic of an analog type Hall sensor;

Fig. 4 is a waveform diagram provided for explaining operation of detecting a position of a rotor;

Fig. 5 is a flowchart showing an example of a processing of detecting the position of the rotor;

Fig. 6 is an explanatory view similar to Fig. 2 showing a second embodiment of the invention;

Fig. 7 is a waveform diagram provided for explaining operation of detecting a position of a rotor according to the second embodiment;

Fig. 8 is a flowchart showing an example of a processing of detecting the position of the rotor according to the second embodiment; and

Fig. 9 is a waveform diagram showing a magnetic pole detecting signal and a conducting current waveform in a conventional brush DC motor.

[0014] An explanation will be given of embodiments of the invention in reference to the drawings as follows.

[0015] Fig. 1 is a sectional view showing a first embodiment when the invention is applied to a brushless DC motor.

[0016] In the drawing, numeral 1 designates a motor case constituted by a stator yoke 2 in a cylindncal shape and bearing brackets 3 and 4 closing both ends thereof and a rotor 5 is supported in the motor case 1 rotatably by ball bearings 6 and 7 arranged at the bearing brackets 3 and 4.

[0017] The rotor 5 is constituted by a rotating shaft 8 rotatably supported by the ball bearings 6 and 7, a rotor yoke 9 in a cylindrical shape fitted to the rotating shaft 8 in the motor case 1 and permanent magnets 10 formed at an outer peripheral face of the rotor yoke.

[0018] In this case, as shown by Fig. 2, the permanent magnets 10 are constituted by 8 poles of magnetic poles MP1 through MP8 magnetized in N poles and S poles alternately in the circumferential direction.

[0019] In the meantime, the stator yoke 2 is arranged with, for example, 9 slots of magnetic legs ML1 through ML9 at positions opposed to the permanent magnets 10 of the rotor 5. As shown by Fig. 2, the stator 11 is constituted by winding three phases of armature coils LU, LV and LW at respectives of the magnetic legs ML1 through ML3, ML4 through ML6 and ML7 through ML9 and according to the armature coils LU, LV and LW, ends C on one side of these are connected to each other to thereby constitute star connection.

[0020] Further, the stator yoke 2 is arranged with a support piece 12 extended to a position opposed to an end face of the permanent magnet 10 of the rotor 5 and two analog type Hall sensors 13A and 13B constituting U phase magnetism detecting means are arranged at positions of the support piece 12 opposed to the end face of the permanent magnet 10.

[0021] As shown by Fig. 3, the analog type Hall sensors 13A and 13B output, as analog magnetism detecting signals, analog induced voltages in a shape of a sine wave, the phases of which are advanced by 90° in electrical angle relative to magnetic fluxes generated by the magnetic poles MP1 through MP8 constituting the permanent magnets 10 as illustrated by a broken line, and arranged at mechanical angle positions shown by Fig. 2 such that when the rotational direction of the rotor 5 is in the clockwise direction, the phase of an analog magnetism detecting signal SB of the Hall sensor 13B shown by Fig. 4(b) is advanced by 90° in electrical angle relative to that of an analog magnetism detecting signal SA of the Hall sensor 13A shown by Fig. 4(a).

[0022] That is, the analog type Hall sensor 13A for

[0034] That is, according to the second embodiment, as shown by Fig. 6, there is constructed a constitution similar to that of the first embodiment shown by Fig. 2 except that there is applied a digital type Hall sensor 14 for outputting magnetic fluxes generated at the magnetic poles MP1 through MP8 constituting the permanent magnet 10 as digital magnetism detecting signals of a binary signal in place of the analog type Hall sensor 13B, the same notations are attached to portions in correspondence with those in Fig. 2 and a detailed explanation thereof will be omitted.

[0035] According to the second embodiment, although as shown by Fig. 7(a) the analog magnetism detecting signal SA similar to that in the first embodiment is outputted from the analog type Hall sensor 13A, as shown by Fig. 7(b), a digital magnetism detecting signal SD comprising a binary signal, the phase of which is advanced by 90° in electrical angle relative to the analog magnetism detecting signal SA, is outputted from the digital type Hall sensor 14.

[0036] Therefore, when the digital magnetism detecting signal SD is brought into an ON state, the analog magnetism detecting signal SA falls in a range of -90° through 90° and when the digital magnetism detecting signal SD is brought into an OFF state, the analog magnetism detecting signal SA falls in a range of 90° through 270° and therefore, by inputting the analog magnetism detecting signal SA and the digital magnetism detecting signal SD into the microcomputer for controlling to drive the brushless DC motor and carrying out a rotor position detecting processing shown by Fig. 8, the rotor position can accurately be detected in electrical angle.

[0037] That is, the rotor position detecting processing is executed as a timer interruption processing at respective predetermined time (for example, 10 msec). First, instantaneous values of the analog magnetism detecting signal SA and the digital magnetism detecting signal SD are read at step S11. Successively, the operation proceeds to step S12 and determines whether the digital magnetism detecting signal SD is brought into the ON state. In the case of the ON state, it is determined that the analog magnetism detecting signal SA falls in a range of -90° (=270°) through 90° and the operation proceeds to step S13. The timer interruption processing is finished by calculating the electrical angle θ_E based on the instantaneous value of the analog magnetism detecting signal SA in reference to the electrical angle calculation map previously stored. Further, when the determination result at step S12 indicates the OFF state, it is determined that the analog magnetism detecting signal SA falls in a range of 90° through 270° and the operation proceeds to step S14. The timer interruption processing is finished by calculating the electrical angle θ_E based on the instantaneous value of the analog magnetism detecting signal SA in reference to the previously stored electrical angle calculation map.

[0038] In this case, the processing of Fig. 8 corresponds to the rotational position detecting means.

[0039] In this way, also in the second embodiment, the rotor position can accurately be detected by using the analog type Hall sensor 13A and the digital type Hall sensor 14, further, the digital type Hall sensor 14 is inexpensive in comparison with the analog type Hall sensor 13A and therefore, the rotor position detecting apparatus can be fabricated at a low cost in comparison with that in the first embodiment.

[0040] Further, although according to the first and the second embodiments, an explanation has been given of the case in which the analog type Hall sensor 13A and the analog type Hall sensor 13B or the digital type Hall sensor 14 are installed at the positions shown by Fig. 2, these may be arranged at positions shifted from each other by the mechanical angle of 90° (electrical angle of 360°) multiplied by an integer. When these sensors are used in inverse signs, the sensors may be arranged at positions shifted from each other by the mechanical angle of 45° (electrical angle of 180°) multiplied by an integer. Further, the positions of installing the analog type Hall sensor 13A and the analog type Hall sensor 13B or the digital type Hall sensor 14 relative to each other are not limited to those having the mechanical angle of 22.5° (electrical angle of 90°) as interval therebetween but may be installed at arbitrary mechanical angle positions and in this case, the phase of the output of either one of the analog type Hall sensor 13A and the analog type Hall sensor 13B or the digital type Hall sensor 14 may be corrected relative to the phase of other to constitute the interval of 90° in electrical angle or electrical angle 90° multiplied by an integer.

[0041] Further, although according to the above-described first and second embodiments, an explanation has been given of the case in which the Hall sensors 13A, 13B and 14 are arranged at the end face of the rotor 5 in the axial direction, when the analog type Hall sensor 13A is placed between the slots, since the stator 11 is of 9 slots, a deviation from the center in the circumferential direction of the magnetic leg ML2 to slots on both sides, becomes ±(80+160n) (n=0 through 4)° in electrical angle. The phase of induced voltage of the analog type Hall sensor 13A is advanced by 90° in electrical angle relative to the position of the magnetic pole of the rotor 5 relative to the magnetic leg ML2 and therefore, the deviation in the case of placing the analog type Hall sensor 13A between the slots becomes 90±(80+160n)° in electrical angle and by taking the shift amount into account, the rotor positions relative to centers in the circumferential direction of central magnetic legs of the respective phases of U, V and W phases of the stator 11 can accurately be detected.

[0042] Further, although according to the above-described first and second embodiments, an explanation has been given of the case in which the invention is applied to the brushless DC motor of the inner rotor type, the invention is not limited thereto but the invention is applicable to an alternating current motor having a

cles using both an engine and an electric motor.

7. Electrical driving apparatus as claimed in at least one of the preceding claims 1 to 6, wherein the position of the rotor by the magnetism and rotor position detecting means is detected continuously.

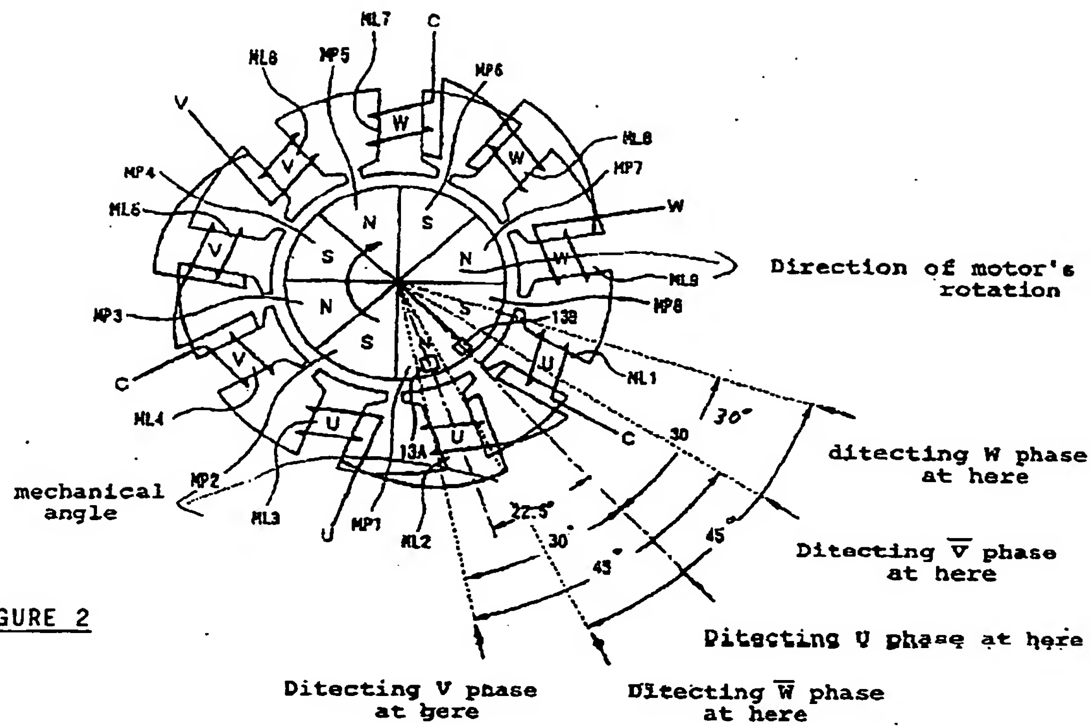

FIGURE 2

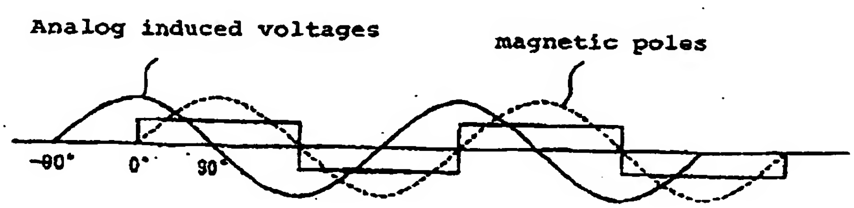

FIGURE 3

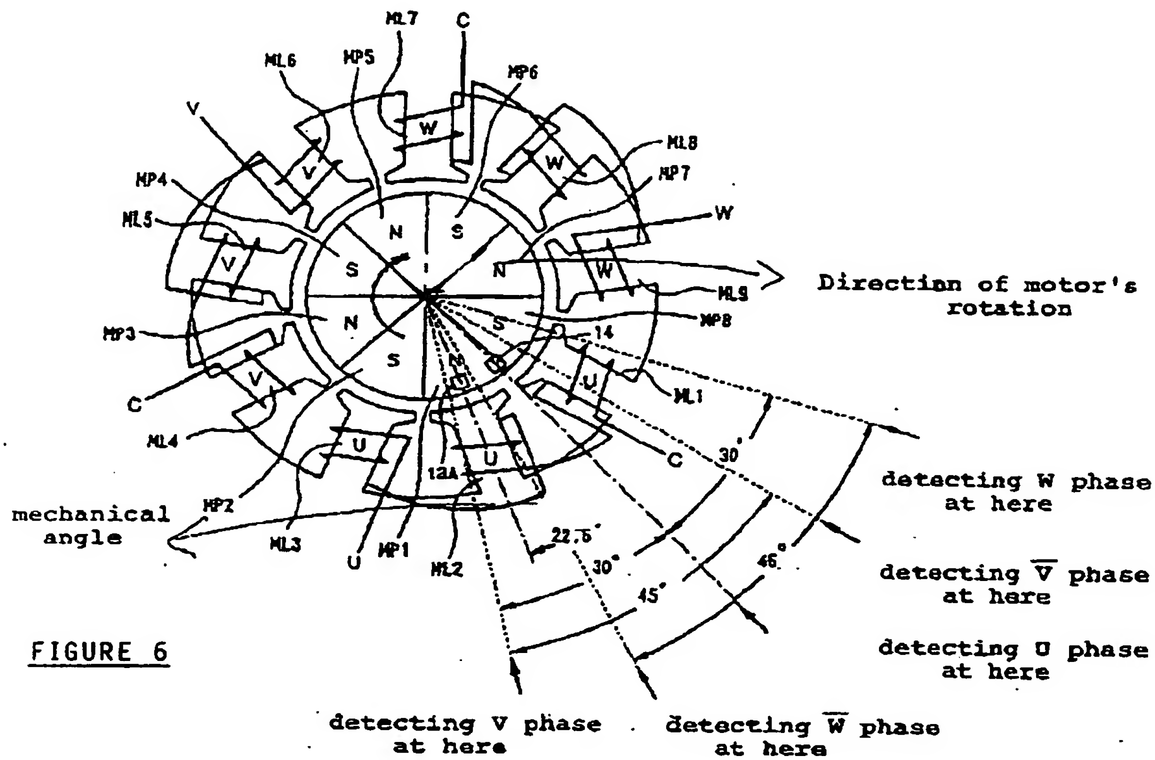

FIGURE 6

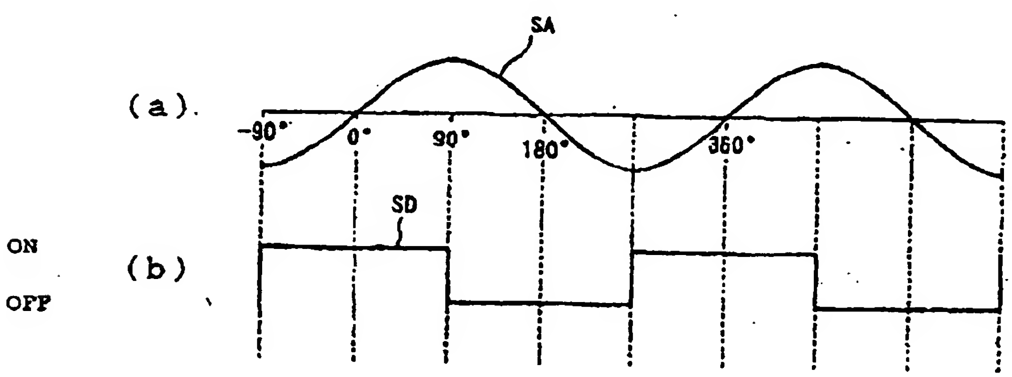

FIGURE 7

(19) Europäisches Patentamt
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(11) EP 1 093 210 A3

(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:
19.12.2001 Bulletin 2001/51

(51) Int Cl.7: **H02K 29/08**, H02P 6/00

(43) Date of publication A2:
18.04.2001 Bulletin 2001/16

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(71) Applicant: **YAMAHA HATSUDOKI KABUSHIKI KAISHA**
Iwata-shi Shizuoka-ken (JP)

(72) Inventor: **Taiken, Matsui,**
c/o Yamaha Hatsudoki K.K.
Shizuoka-ken (JP)

(74) Representative:
Grünecker, Kinkeldey, Stockmair & Schwanhäusser Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

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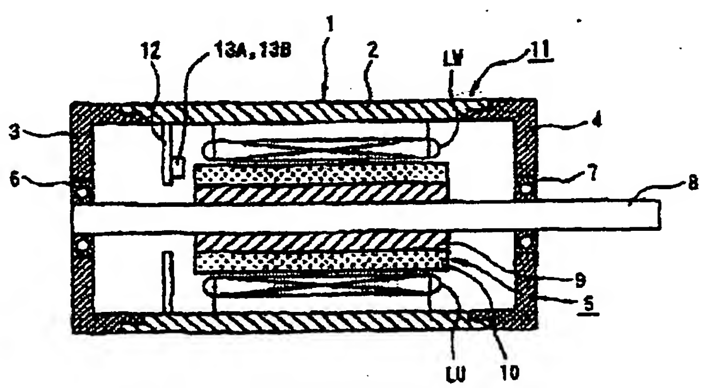

FIGURE 1

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EUROPEAN SEARCH REPORT

Application Number
EP 00 12 2557

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	29 October 2001	Roy, C

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